

piece, just three times the quantity of homogeneous glass that the Vienna discs required, and though I am not of course in the secrets of the glass manufacturers, it appears to me that the chances of obtaining 40-inch discs in the present state of the art are remote.

"The other difficulties of manufacture of refractors consist in the nicety of the operation connected with the calculations of the curves, the manipulation of such extremely costly material, and the enormous labour and trouble of the figuring and perfecting of the objective. All these, however, I have no doubt will be overcome by the optician for any size which the glass-maker is at all likely to produce.

"Now, as to the difficulties connected with the manufacture of reflectors, whether metallic or silver on glass.

"First, as to the difficulty of producing the metallic or glass disc to work upon.

"Lord Rosse has succeeded years since in casting, annealing, and perfecting discs of six feet in diameter, and any difficulties he met with were not such as to lead me to the belief that the limit of possible size has been by any means reached. As regards glass mirrors, the question has never been discussed, for in any sizes that have been made up to the present time, it was only necessary to go to the plate-glass manufacturers and say, 'I want a disc of crown glass of such a diameter and such a thickness,' and forthwith the glass disc was delivered without any trouble; but, when we come to these extraordinary sizes, it is quite a different matter. For the 4-foot disc of glass for the Paris reflector, in place of that which has so recently resulted in failure, the St. Gobain Glass Company require twelve months' time to perfect (although, be it remembered, the quality of the glass is here of no consequence whatever); and I have been myself in correspondence with the principal glass manufacturers here and on the Continent, and not one of them is willing to undertake even a 6-foot glass disc; so that it would appear that, above that size, the silver-on-glass mirrors are out of the question.

"This much, however, is to be said: If anyone were to go to a brass- or bell-founder's and ask them to undertake a speculum of six feet in diameter, he would almost certainly be met with a refusal; and yet Lord Rosse has proved the feasibility of it. And so, reasoning by analogy, might the manufacture of a six- or eight-foot glass mirror be possible, if undertaken in the same scientific spirit in which Lord Rosse undertook his. I answer to this—Yes; perfectly true; but this is too purely a speculative matter to be considered at the present day in the choice of telescopes.

"The other great difficulty in the manufacture of reflectors is the annealing of the disc, and I believe it is this difficulty which limits to so narrow an extent the production of glass discs for silver-on-glass mirrors."

We can abundantly gather from this paper of Mr. Grubb's that our opticians are doing all that lies in their power to give us increased power in the future. The fact that in the last few years one refractor of 25 inches, and two of 26 inches, have been acquired to science, leads us to hope that for the present progress will lie in increasing the dimensions of that instrument. Mr. Grubb, indeed, has already in hand one of 27 inches for the Austrian Government. The *contretemps* to the four-foot Foucault in Paris will also help to set the tide in the same direction.

From what has preceded it will be seen that each increase in the power of the telescope is of little avail unless we use it in purer and purer air. It is quite true that in the telescope much of the injury to definition arising from currents in the tube may be got rid of by the employment of lattice-work; but this, of course, will not lessen the atmospheric effects of the column of air ever increasing in diameter between the telescope and the object.

Prof. Piazzzi Smyth's astronomical experiences on

Teneriffe will still be in the minds of many of our readers. He showed that an enormous advantage was secured from observations so soon as half the atmosphere was below the observer. A more recent experiment by Dr. Draper, however, has shown that it will not do to go blindly and put the telescope on any high mountain. The conditions of each place from this single point of view must be carefully studied. Summing up his experiences of the Rocky Mountains up to heights of 10,000 feet, Dr. Draper says:—

"On the whole, it may be remarked of this mountain region that the astronomical conditions, especially for photographic researches, is unpromising. In only one place were steadiness and transparency combined, and only two nights out of fifteen at the best season of the year were exceptionally fine. The transparency was almost always much more marked than at the sea-level, but the tremulousness was as great or even greater than near New York. It is certain that during more than half the year no work of a delicate character could be done. . . . Apparently therefore, judging from present information, it would not be judicious to move a large telescope and physical observatory into these mountains with the hope of doing continuous work under the most favourable circumstances."

J. NORMAN LOCKYER

(To be continued.)

ELECTRICAL ANALOGIES WITH NATURAL PHENOMENA

WITHIN the last few years M. Gaston Planté has at intervals described a series of very curious phenomena produced by electric currents of high tension, and has pointed out numerous analogies which they present with several atmospheric and cosmical phenomena. Without committing ourselves to the belief that these analogies are real, the phenomena described are so interesting that we are glad to be able, by the kindness of M. Planté, to reproduce some illustrations of them.

To obtain electric currents of high tension M. Planté has employed secondary batteries of sheets of lead, which, as is known, constitute powerful accumulators of voltaic electricity. By associating a very great number of batteries uniting from 400 to 800 of these secondary couples, a discharge is obtained equivalent, according to M. Planté, to that of from 600 to 1,200 Bunsen couples arranged in tension.

Fig. 1 represents the arrangement of 400 secondary elements divided into ten batteries. This is the source of electricity employed for some of the earlier experiments which we are about to describe. The more recent ones have been made with 800 secondary elements arranged in twenty batteries of forty couples. A second series of batteries similar to the first is arranged in another room, and the current which it furnishes is joined to that of the first series by conducting wires suitably adjusted. These batteries, associated at first in simple circuit by means of commutators, do not require to be charged all at once like two Grove or Bunsen couples. When they have not been out of use for too long a time a few hours suffice to charge them. We may then, by turning the commutators, unite all the secondary elements in tension and use at will, either in a few seconds or in a longer time, the enormous quantity of electricity resulting from the chemical work accumulated during two hours by Grove or Bunsen batteries.

Such was the powerful means adopted by M. Planté in making his late experiments. In his earlier experiments he used a much simpler apparatus.

The gyratory movements accompanied with luminous effects which M. Planté had observed with a powerful current of electricity, and the spherical and annular forms manifested by bodies submitted to that action, suggested to M. Planté the probability of the electric origin of the forms of some of the nebulous masses of matter which

are not resolvable, and particularly of those which assume a spiral form.

He describes an experiment in which a cloud of metallic matter attracted to an electrode by the electric current assumes in the centre of the liquid a gyratory spiral movement under the influence of a magnet.¹ A glance at Figs.

2, 3, and 4, which represent this experiment, is sufficient to enable us to recognise their similarity to the forms of spiral nebulae described by Lord Rosse. Some of these have the curvature of their spirals tending in a direction opposite to that of the hands of a watch, like those in Fig. 3, such as in the nebula

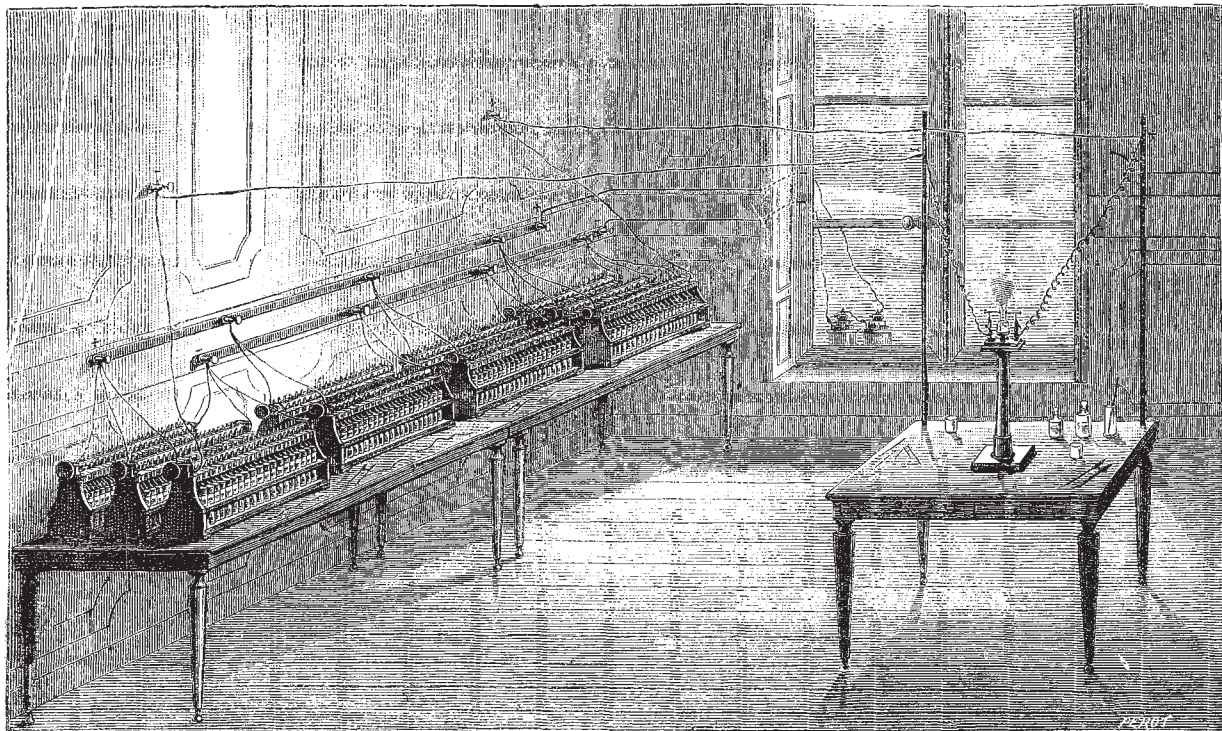


FIG. 1.—Arrangement of 400 couples in ten batteries for experiments with electric currents of high tension.

in Berenice's Hair; others have their spirals in the same direction as the hands of a watch, like that of Fig. 4, as in the nebula in Canes Venatici. M. Planté is inclined to believe that, in presence of an analogy so striking, we are

authorised to think that the nucleus of these nebulae may be constituted by a true centre of electricity; that their spiral form may be determined by the near presence of celestial bodies strongly magnetic, and that the direction

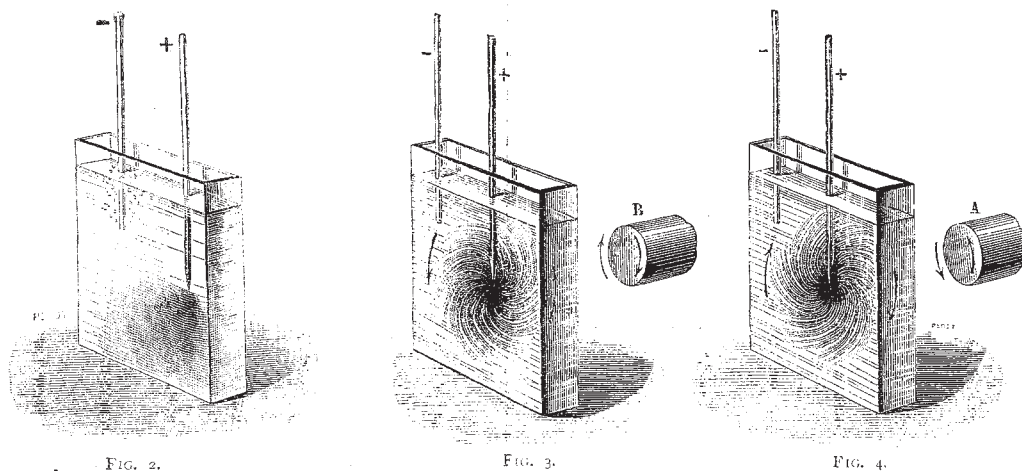


FIG. 2.—Cloud of metallic oxide formed in a voltameter before the approach of a magnet. FIGS. 3 and 4.—Gyratory movement communicated to the cloud of metallic matter by the action of a magnet.

of curvature of the spirals may depend on the nature

It is easy to reproduce this experiment and even throw the effect on a screen, by means of an electric current equivalent to that of fifteen Bunsen elements. The electrodes are copper wires; the liquid is acidulated with 1-10th of sulphuric acid. From the extremity of the positive wire escapes, with a slight hissing sound, a thick cloud of the protoxide of copper or of finely-divided

of the magnetic pole turned towards the nebula. He copper, and this wire takes the form of a very sharp point. The arrows around the spirals in the figures indicate the gyratory movement which this cloud assumes under the influence of a magnet; and the arrows around the magnet represent the direction of the electro-magnetic currents: B is the north and A the south pole.

suggests that if we had powerful enough telescopes, the neighbourhood of the nebulae should be searched to discover stars capable of exercising such a magnetic influence. If such a star was found likely to act thus on any nebula, then the line passing through the centre of the nebula and the star should be searched to discover if, at the other magnetic pole of the star, a second nebula did not exist, with its spirals in a contrary direction to those of the former.

M. Planté states that with a much more intense source of electricity he has observed small luminous rings, composed of incandescent particles, altogether detached from the elec-



FIG. 5.—Luminous globule formed at the surface of a liquid by an electric current of high tension.

trode. These rings, the centre of which was agitated by a small liquid whirlpool, moved in the interval comprised between the electrode and a very large luminous ring formed round about by the shock of the electric current against the sides of the voltameter.

The Formation of Hail.—In a paper in the *Comptes Rendus*, t. lxxxi. p. 616, M. Planté had shown the influence which atmospheric electricity in a state of discharge must have in the formation of hail, not by producing the cold necessary to congelation, as is sometimes supposed, but by exercising, on the contrary, a powerful heating action,



FIG. 6.—Shower of aqueous globules produced by a current of double the tension of the preceding.

capable of rapidly vaporising the moisture, and of projecting the vapour into the cold regions of the atmosphere. To succeed in explaining the part played by electricity in this natural phenomenon, it is necessary to point out the mechanical action which may result from the passage of the electric fluid into the midst of aqueous masses, and thus to project into the air liquid globules susceptible of being transformed into hailstones.

In previous experiments M. Planté showed that with an intense source of voltaic electricity, the immersion of the positive wire in a conducting liquid, such as salt water, determines the aggregation of aqueous molecules around

the electrode in the form of a luminous spheroid, in consequence of a double simultaneous effect of flow and aspiration, or of passage in two directions which seems peculiar to the electric current (Fig. 5).

But by employing a current still more intense, resulting from the discharge of a battery of 400 secondary couples, he obtains, by the immersion of the positive wire, instead of a single globule, a shower of innumerable ovoid globules, which succeed each other with excessive rapidity, and are projected to more than a metre distance from the vessel in which the experiment is made. The spark produced at the same time at the surface of the liquid presents the form of a corona or aureole of many points, from which burst forth the aqueous globules (Fig. 6).

The metallic property of the electrode is not necessary to obtain this effect. A fragment of filter paper, moistened with salt water, in communication with the positive pole, also produces the phenomenon, and constitutes a humid mass analogous, to a certain point, with that of a cloud from which proceeds an electric current. If, instead of encountering a deep layer of liquid, the current meets with a moist surface such as the sides or the inclined bottom of a basin, the heating effects predominate, the aureole is very brilliant, and the water is rapidly transformed into vapour (Fig. 7).

The action of the current then differs according to the resistance which is opposed to it, and we find here a new

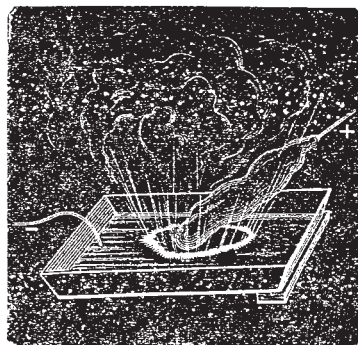


FIG. 7.—Jets of vapour and luminous streaks produced by an electric current of high tension on meeting with a moist surface.

example of the reciprocal substitution of heat and mechanical work resulting from the electric shock. When the work represented by the violent projection of the liquid appears, there is neither heat nor vapour developed, and when no visible work is accomplished, when the liquid is not projected, heat is engendered and vapour disengaged.

M. Planté sums up the results of these experiments thus :—

1. Electric discharges produced in the midst of clouds may, according to the greater or less density of these moist conductors, determine their reduction into vapour, or their instantaneous aggregation into globules of a volume much greater than that of the globules of the cloud, and the liquid bombs thus formed may be projected to great heights, where the temperature is notably lower than that of the medium in which the discharges are produced.

2. The formation of hailstones, in the case where they do not present a series of opaque and transparent layers, but a structure radiating from the centre, is also explained by such a mechanical action; they must be produced by a single jet, and congealed under the same volume which they had at the moment when they were shot forth by the electric current.

3. The ovoid or pyramidal form of these hailstones, as also their angular parts, aspirates or protuberances, are due to their electric origin.

4. The gleam sometimes emitted by hailstones is due also to electricity; for although in the experiments described, it could not be distinguished whether the globules were self-luminous or shone by the reflection of the spark, it is probable that they were also rendered phosphorescent by the electric current which they contained.

M. Planté admits the action of other agents, such as wind currents, in the formation of hail, but only as accessories to the action of electricity. They are concurrent causes which only prepare the conditions favourable to its production, while electricity is the efficient cause which, by its very presence in the clouds and by the instantaneous power of its discharges, determines the sudden formation and the fall of the meteor.

M. Planté is still prosecuting his researches on this subject.

(To be continued.)

ENTOMOLOGY IN AMERICA

THE U.S. Entomological Commission which was organised and placed under the auspices of Prof. Hayden's Geological Survey for the purpose of investigating and reporting the entire subject of insect ravages throughout the western regions of our continent, have completed their field labour for the present season.

The members of the Commission have been busily engaged in the preparation of the several parts of their Annual Report, and will soon meet in Washington, where they will have a protracted sitting to get everything ready for the printer. This report is looked for with much interest by the farmers of the west, and the character of the commissioners is a guarantee that it will be creditable from the scientific, and valuable from the practical, standpoint. The Report will contain sixteen chapters, under the following heads:—Introduction, Riley; Chronological History, Packard; Statistics of Losses, Thomas; Classification and Nomenclature, Thomas; Geographical Distribution, Thomas and Packard; Migration and Meteorology, Packard and Thomas; Original Permanent Breeding Grounds, Riley, Packard, and Thomas; Habits and Natural History, Riley; Embryology, Packard; Metamorphoses, Riley and Packard; Invertebrate Enemies, Riley; Vertebrate Enemies, Thomas; Remedies and Devices for Destruction, Riley; Prairie Fires *versus* Locust Injury, Riley; Agricultural Bearings of the Subject, Thomas; Ravages of other Locusts, Packard and Riley; Locust Ravages in other Countries.

These chapters will embrace many sub-chapters, and the Report will be as exhaustive as the limited time for its preparation will permit.

In Chapter IV. the western extension and the northern and eastern limit of the species' range are fully given.

In Chapter V. the laws governing its migrations are for the first time defined. A very large number of data have been collected in reference to the subjects of this chapter. Not only are the general laws governing the movements of the insect now defined, showing a regular migration southward and return migration northward, which may be counted on and foreseen; but many important and highly interesting facts in reference to their local flights are brought to light, which will henceforward form a part of the history of the insect.

In Chapter VII. several other laws governing the species are also adduced; and the importance of the discovery of the laws which regulate the doings and movements of the pest, cannot be over-estimated. In said Chapter VII. many new facts will for the first time appear, and all that is definite and accurate be made known.

In Chapter X. many new discoveries will be recorded, some of them of great scientific interest and importance. Of these may be mentioned the transformation of the

silky mite (*Trombidium sericeum*). This is an eight-legged creature, which preys on the locust eggs. It is proved to be the mature form of the little six-legged mite (*Astoma gryllaria*) which is parasitic on the locust. Insects described under different genera are thus proved to be specifically identical. The life-history of the blister-beetles will also be given, their larvæ feeding upon locust eggs, and undergoing singular changes called hypermetamorphoses. The interest attaching to this discovery among entomologists, as well as among farmers, is best appreciated when it is considered that absolutely nothing has heretofore been known of the larval habits of these blister-beetles, notwithstanding the fact that for half a century much attention has been given to the subject by scientific men, on account of the commercial value of *Cantharis*, or Spanish fly, and of the great injury to potatoes and other plants committed by several of our American species.

In Chapter XI. are given the locust feeding habits of many western animals not heretofore known to have that habit, and the good offices of birds are especially made manifest, examinations of the stomachs of over ninety species and 630 specimens having been made with special reference to their locust-eating habits. The record in reference to these examinations is very full, giving the dates, the locality, the common and scientific names of the species, and the number of locusts and other insects found in each. The value heretofore placed on these aids by entomologists is fully sustained by this record.

In Chapter XII., which will be one of the most extended and most important practically, it is clearly shown that the young locusts may be controlled, and by what means; while the way is pointed out how to better control the winged insects. Many valuable devices for destruction will be illustrated, among them one invented by Prof. Riley, which gave great satisfaction, and will, it is believed, supersede all others as a cheap and practicable remedy applicable at any season, whether the plants or the insects be small or large.

In Chapters II. and IV. are given statistics showing the immense losses inflicted on western agriculturists by the locust. These chapters also show what crops are most liable to injury and what are most easily protected; also the best methods of cropping in order to reduce the injury to a minimum. A chemical analysis of the dead locusts has been made, and is unusually interesting. The insects furnish a new oil, which will be christened Coloptine, and a very large percentage of pure formic acid. Though this acid exists in the ant and some other insects, it is with difficulty obtained in large quantities, whereas by the action of sulphuric acid upon the locust juices it passes off with great readiness and in remarkable quantity and gravity. The various uses of this acid whether as a therapeutic agent or as laboratory re-agents, &c., are capable of great and valuable extension when it can once be obtained so readily and in such quantity.

The Report is expected to make about 500 pages, and will, it is hoped, be published in February or March. Although the Commissioners have divided the labour among them, the Report will form one complete whole, as the work of each will be discussed and revised by the Commission as a whole.

The Annual Report, which is intended more particularly for the practical farming public, will be followed by memoirs of a more purely scientific nature—one by Dr. Packard on Anatomy and Embryology; one by Prof. Riley on the Natural History of other Locusts, and one by Prof. Thomas on the classification of the *Acrididae*.

While it has been the object of the Commission to cover as much ground as possible so as to make the Annual Report as full and valuable as the time would permit, there yet remain several important subjects that it has so far been impossible to properly and exhaustively study. The territory affected is so vast, embracing over